

WHAT IS CLAIMED IS:

1 1. A process for sensor obscuration analysis, implemented via a programmable  
2 machine, the process comprising:  
3 animating a three-dimensional visualization of a satellite that includes a sensor  
4 object, the sensor object having a boresight and a sensor pattern;  
5 selecting a view perspective from the sensor object along the boresight;  
6 selecting objects of a satellite system analysis scenario that are capable of causing  
7 obscuration;  
8 assigning a first color to the selected objects, while assigning a second color to  
9 unselected objects and background of the satellite system analysis scenario;  
10 assigning a third color to the sensor pattern, such that, when the sensor pattern is  
11 superimposed over a visual display of the satellite system analysis scenario, portions of the  
12 sensor pattern that overlap with unselected objects and background appear in a different  
13 color than do portions of the sensor pattern that overlap with selected objects;  
14 counting and recording the quantities of pixels of each color in the sensor pattern,  
15 the counting and recording being carried out at each time step of animation of the satellite  
16 system analysis scenario;  
17 providing a graphical display to a user, during the animation, portraying the  
18 amount of obscuration of the sensor pattern, and source of obscuration of the sensor  
19 pattern, over a predetermined time period; and  
20 calculating the percentage of obscuration over said predetermined time period on  
21 the basis of the recorded pixel quantities, the calculated percentage of obscuration being  
22 displayed to a user.

1           2. The process for sensor obscuration analysis of claim 1, the process further  
2 comprising:  
3           translating a projection of the sensor pattern so that the sensor pattern is projected  
4 from edges of the sensor object.

1           3. The process for sensor obscuration analysis of claim 1, wherein the graphical  
2 display and the displayed calculated percentage of obscuration is used for planning  
3 missions to avoid sensing activities during periods of excessive obscuration.

1           4. The process of sensor obscuration analysis of claim 1, wherein the graphical  
2 display and the displayed calculated percentage of obscuration is used for planning  
3 missions to schedule maneuvers to eliminate or reduce obscuration.

1           5. The process of sensor obscuration analysis of claim 1, wherein the graphical  
2 display and the displayed calculated percentage of obscuration is used for the purpose of  
3 determining whether re-positioning of objects attached to the satellite can eliminate or  
4 reduce obscuration.

1           6. The process of sensor obscuration analysis of claim 1, wherein the counting and  
2 recording of pixels is carried out such that pixels near the edge of the sensor pattern are  
3 given a reduced weight to compensate for the fact that a display screen of the  
4 programmable machine is flat, while the sensor pattern is spherical.

1           7. A method of analyzing sensor obscuration using a satellite system analysis  
2 program having animated three-dimensional visualization of a satellite that includes a  
3 sensor object, the sensor object having a boresight and a sensor pattern, the method  
4 comprising:

5 selecting a view perspective from the sensor object along the boresight;  
6 selecting objects of a satellite system analysis scenario that are capable of causing  
7 obscuration;  
8 assigning a first color to the selected objects, while assigning a second color to  
9 unselected objects and background of the satellite system analysis scenario;  
10 assigning a third color to the sensor pattern, such that, when the sensor pattern is  
11 superimposed over a visual display of the satellite system analysis scenario, portions of the  
12 sensor pattern that overlap with unselected objects and background appear in a different  
13 color than do portions of the sensor pattern that overlap with selected objects;  
14 counting and recording the quantities of pixels of each color in the sensor pattern,  
15 the counting and recording being carried out at each time step of animation of the satellite  
16 system analysis scenario;  
17 providing a graphical display to a user, during the animation, portraying the  
18 amount of obscuration of the sensor pattern, and source of obscuration of the sensor  
19 pattern, over a predetermined time period; and  
20 calculating the percentage of obscuration over said predetermined time period on  
21 the basis of the recorded pixel quantities, the calculated percentage of obscuration being  
22 displayed to the user.

1 8. The method of analyzing sensor obscuration of claim 7, the method further  
2 comprising:  
3 translating a projection of the sensor pattern so that the sensor pattern is projected  
4 from edges of the sensor object.

1 9. The method of analyzing sensor obscuration of claim 7, wherein the graphical  
2 display and the displayed calculated percentage of obscuration is used for planning  
3 missions to avoid sensing activities during periods of excessive obscuration.

1 10. The method of analyzing sensor obscuration of claim 7, wherein the graphical  
2 display and the displayed calculated percentage of obscuration is used for planning  
3 missions to schedule maneuvers to eliminate or reduce obscuration.

1 11. The method of analyzing sensor obscuration of claim 7, wherein the graphical  
2 display and the displayed calculated percentage of obscuration is used for the purpose of  
3 determining whether re-positioning of objects attached to the satellite can eliminate or  
4 reduce obscuration.

1 12. The method of analyzing sensor obscuration of claim 7, wherein the counting  
2 and recording of pixels is carried out such that pixels near the edge of the sensor pattern  
3 are given a reduced weight to compensate for the fact that a display screen is flat, while  
4 the sensor pattern is spherical.

1 13. A computer program product for enabling a computer to perform analysis of  
2 sensor obscuration, the computer program product comprising:  
3 software instructions for enabling the computer to perform predetermined operations, and  
4 a computer readable medium embodying the software instructions;  
5 the predetermined operations comprising:  
6 animating a three-dimensional visualization of a satellite that includes a sensor object,  
7 the sensor object having a boresight and a sensor pattern;  
8 selecting a view perspective from the sensor object along the boresight;

9 selecting objects of a satellite system analysis scenario that are capable of causing  
10 obscuration;  
11 assigning a first color to the selected objects, while assigning a second color to  
12 unselected objects and background of the satellite system analysis scenario;  
13 assigning a third color to the sensor pattern, such that, when the sensor pattern is  
14 superimposed over a visual display of the satellite system analysis scenario,  
15 portions of the sensor pattern that overlap with unselected objects and background  
16 appear in a different color than do portions of the sensor pattern that overlap with  
17 selected objects;  
18 counting and recording the quantities of pixels of each color in the sensor pattern, the  
19 counting and recording being carried out at each time step of animation of the  
20 satellite system analysis scenario;  
21 providing a graphical display to a user, during the animation, portraying the amount of  
22 obscuration of the sensor pattern, and source of obscuration of the sensor pattern,  
23 over a predetermined time period; and  
24 calculating the percentage of obscuration over said predetermined time period on the  
25 basis of the recorded pixel quantities, the calculated percentage of obscuration  
26 being displayed to the user.

1 14. The computer program product of claim 13, the predetermined operations  
2 further comprising:  
3 translating a projection of the sensor pattern so that the sensor pattern is projected  
4 from edges of the sensor object.

1 15. The computer program product of claim 13, wherein the graphical display and  
2 the displayed calculated percentage of obscuration is used for planning missions to avoid  
3 sensing activities during periods of excessive obscuration.

1 16. The computer program product of claim 13, wherein the graphical display and  
2 the displayed calculated percentage of obscuration is used for planning missions to  
3 schedule maneuvers to eliminate or reduce obscuration.

1 17. The computer program product of claim 13, wherein the graphical display and  
2 the displayed calculated percentage of obscuration is used for the purpose of determining  
3 whether re-positioning of objects attached to the satellite can eliminate or reduce  
4 obscuration.

1 18. The computer program product of claim 13, wherein the counting and  
2 recording of pixels is carried out such that pixels near the edge of the sensor pattern are  
3 given a reduced weight to compensate for the fact that a display screen of the  
4 programmable machine is flat, while the sensor pattern is spherical.

1 19. A sensor obscuration analysis computer program product, which has a  
2 computer program stored on a machine-readable medium, the computer program  
3 comprising:

4 an animation code segment providing for animated three-dimensional visualization  
5 of a spacecraft having a sensor object, the sensor object having a boresight and a sensor  
6 pattern;

7 a perspective selection code segment providing for a visualization view from the  
8 perspective of said sensor object, along said sensor object's boresight;

9 a selection code segment that enables selection of obscuring objects to be taken  
10 into account in the obscuration analysis;

11 a simplification code segment that simplifies visual display provided by said  
12 animation code segment to show the selected obscuring objects in a first color and show  
13 unselected objects and background in a second color;

14 a distinguishing code segment that assigns a third color to portions of the sensor  
15 object's field of view that are obscured by the selected obscuring objects and a fourth  
16 color to those portions of the sensor object's field of view that are not obscured, to thereby  
17 distinguish obscured portions of the sensor object's field of view from unobscured  
18 portions of the sensor object's field of view;

19 a quantifying code segment that counts and records a quantity of pixels  
20 corresponding to obscured portions of the sensor object's field of view at each of plural  
21 animation time steps, and that counts and records a quantity of pixels corresponding to  
22 unobscured portions of the sensor object's field of view at each of the plural animation  
23 time steps; and

24 a results code segment that calculates, based on the quantities of pixels counted  
25 and recorded by said quantifying code segment, and reports to a user percent obscuration  
26 of the sensor object's field of view over a predetermined time period.

1 20. The sensor obscuration analysis computer program product of claim 19, the  
2 computer program further comprising:

3 a projection code segment that projects said sensor pattern from edges of said  
4 sensor object.

1           21. The sensor obscuration analysis computer program product of claim 19, said  
2           obscuring objects being selected from the group consisting of: said spacecraft, protrusions  
3           from said spacecraft, a central body about which said spacecraft orbits, and celestial  
4           bodies.

1           22. The sensor obscuration analysis computer program product of claim 19, said  
2           distinguishing code segment including code for determining portions of the sensor object's  
3           field of view that are obscured by the selected obscuring objects by comparing said sensor  
4           pattern with the selected obscuring objects.

1           23. A propagated signal for use in sensor obscuration analysis, the signal being  
2           propagated via a data transmission medium, the propagated signal comprising:

3           an animation signal segment providing for animated three-dimensional  
4           visualization of a spacecraft having a sensor object, the sensor object having a boresight  
5           and a sensor pattern;

6           a perspective selection signal segment providing for a visualization view from the  
7           perspective of said sensor object, along said sensor object's boresight;

8           a selection signal segment that enables selection of obscuring objects to be taken  
9           into account in the obscuration analysis;

10          a simplification signal segment that simplifies visual display provided by said  
11          animation code segment to show the selected obscuring objects in a first color and show  
12          unselected objects and background in a second color;

13          a distinguishing signal segment that assigns a third color to portions of the sensor  
14          object's field of view that are obscured by the selected obscuring objects and a fourth  
15          color to those portions of the sensor object's field of view that are not obscured, to thereby



16 distinguish obscured portions of the sensor object's field of view from unobscured  
17 portions of the sensor object's field of view;

18 a quantifying signal segment that counts and records a quantity of pixels  
19 corresponding to obscured portions of the sensor object's field of view at each of plural  
20 animation time steps, and that counts and records a quantity of pixels corresponding to  
21 unobscured portions of the sensor object's field of view at each of the plural animation  
22 time steps; and

23 a results signal segment that calculates, based on the quantities of pixels counted  
24 and recorded by said quantifying code segment, and reports to a user percent obscuration  
25 of the sensor object's field of view over a predetermined time period.

1 24. The propagated signal for use in sensor obscuration analysis of claim 23, the  
2 propagated signal further comprising:

3 a projection signal segment that projects said sensor pattern from edges of said  
4 sensor object.

5 25. A computer system adapted to analyze sensor obscuration, comprising:

6 a processor, and

7 a memory including software instructions adapted to enable the computer system  
8 to perform operations comprising:

9 animating a three-dimensional visualization of a satellite that includes a sensor object,

the sensor object having a boresight and a sensor pattern;

selecting a view perspective from the sensor object along the boresight;

selecting objects of a satellite system analysis scenario that are capable of causing  
obscuration;

10 assigning a first color to the selected objects, while assigning a second color to  
11 unselected objects and background of the satellite system analysis scenario;  
12 assigning a third color to the sensor pattern, such that, when the sensor pattern is  
13 superimposed over a visual display of the satellite system analysis scenario,  
14 portions of the sensor pattern that overlap with unselected objects and background  
15 appear in a different color than do portions of the sensor pattern that overlap with  
16 selected objects;  
17 counting and recording the quantities of pixels of each color in the sensor pattern, the  
18 counting and recording being carried out at each time step of animation of the  
19 satellite system analysis scenario;  
20 providing a graphical display to a user, during the animation, portraying the amount of  
21 obscuration of the sensor pattern, and source of obscuration of the sensor pattern,  
22 over a predetermined time period; and  
23 calculating the percentage of obscuration over said predetermined time period on the  
24 basis of the recorded pixel quantities, the calculated percentage of obscuration  
25 being displayed to the user.

1 26. The computer system adapted to analyze sensor obscuration of claim 25, said  
2 software instructions included in the memory being further adapted to enable the computer  
3 system to perform operations comprising:  
4 translating a projection of the sensor pattern so that the sensor pattern is projected  
5 from edges of the sensor object.

1 27. Apparatus for analyzing sensor obscuration using a satellite system analysis  
2 program having animated three-dimensional visualization of a satellite that includes a

3 sensor object, the sensor object having a boresight and a sensor pattern, the apparatus  
4 comprising:

5 means for selecting a view perspective from the sensor object along the boresight;

6 means for selecting objects of a satellite system analysis scenario that are capable  
7 of causing obscuration;

8 means for assigning a first color to the selected objects, while assigning a second  
9 color to unselected objects and background of the satellite system analysis scenario;

10 means for assigning a third color to the sensor pattern, such that, when the sensor  
11 pattern is superimposed over a visual display of the satellite system analysis scenario,  
12 portions of the sensor pattern that overlap with unselected objects and background appear  
13 in a different color than do portions of the sensor pattern that overlap with selected  
14 objects;

15 means for counting and recording the quantities of pixels of each color in the  
16 sensor pattern, the counting and recording being carried out at each time step of animation  
17 of the satellite system analysis scenario;

18 means for providing a graphical display to a user, during the animation, portraying  
19 the amount of obscuration of the sensor pattern, and source of obscuration of the sensor  
20 pattern, over a predetermined time period; and

21 means for calculating the percentage of obscuration over said predetermined time  
22 period on the basis of the recorded pixel quantities, the calculated percentage of  
23 obscuration being displayed to the user.

1 28. The apparatus for analyzing sensor obscuration of claim 27, further  
2 comprising:

3 means for translating a projection of the sensor pattern so that the sensor pattern is  
4 projected from edges of the sensor object.

1 29. The apparatus for analyzing sensor obscuration of claim 27, wherein said  
2 means for counting and recording of pixels operates such that pixels near the edge of the  
3 sensor pattern are given a reduced weight to compensate for the fact that a display screen  
4 is flat, while the sensor pattern is spherical.

1 30. A method of upgrading a satellite system analysis program that performs  
2 animated three-dimensional visualization of a satellite, the satellite having a sensor object,  
3 the sensor object having a sensor pattern and a boresight, the method comprising:

4 supplementing the available view perspectives for the satellite system analysis  
5 program so as to include a view from the sensor, along the boresight of the sensor;

6 supplementing the satellite system analysis program with a code segment that  
7 enables a user to select objects to be taken into account for analysis of obscuration of the  
8 sensor pattern as viewed along the boresight of the sensor;

9 supplementing the satellite system analysis program with a code segment that  
10 simplifies visual display, as viewed along the boresight of the sensor, to show selected  
11 objects in a first color and unselected objects and background in a second color;

12 supplementing the satellite system analysis program with a code segment that  
13 assigns colors to a representation of the sensor pattern of the sensor object, so as to  
14 distinguish those portions of the sensor object's field of view that are obscured by selected  
15 objects from those portions of the sensor object's field of view that are not obscured by  
16 selected objects;

17 supplementing the satellite system analysis program with a code segment that  
18 counts and records the quantity of pixels corresponding to obscured and unobscured  
19 portions of the sensor object's field of view at each of plural animation time steps; and  
20 supplementing the satellite system analysis program with a code segment that  
21 calculates, based on recorded quantities of pixels corresponding to obscured and  
22 unobscured portions of the sensor object's field of view at each of plural animation time  
23 steps, an obscuration percentage over a predetermined time period, the results of the  
24 calculations being reported to a user.

31. The method of upgrading a satellite system analysis program of claim 30,  
wherein the objects to be taken into account for obscuration analysis are selected from the  
group consisting of: the satellite, protrusions from the spacecraft, the central body about  
which the satellite orbits, and celestial bodies.

32. The method of upgrading a satellite system analysis program of claim 30, the  
method further comprising:

supplementing the satellite system analysis program with a translation option for  
the sensor object that projects the sensor pattern from the edges of the sensor object.

33. A computer program product for enabling a computer to upgrade a satellite  
system analysis program that performs animated three-dimensional visualization of a  
satellite, the satellite having a sensor object, the sensor object having a sensor pattern and  
a boresight, the computer program product comprising:

software instructions for enabling the computer to perform predetermined operations, and  
a computer readable medium embodying the software instructions;

the predetermined operations comprising:

8 supplementing the available view perspectives for the satellite system analysis  
9 program so as to include a view from the sensor, along the boresight of the sensor;  
10 supplementing the satellite system analysis program with a code segment that enables  
11 a user to select objects to be taken into account for analysis of obscuration of the  
12 sensor pattern as viewed along the boresight of the sensor;  
13 supplementing the satellite system analysis program with a code segment that  
14 simplifies visual display, as viewed along the boresight of the sensor, to show  
15 selected objects in a first color and unselected objects and background in a second  
16 color;  
17 supplementing the satellite system analysis program with a code segment that assigns  
18 colors to a representation of the sensor pattern of the sensor object, so as to  
19 distinguish those portions of the sensor object's field of view that are obscured by  
20 selected objects from those portions of the sensor object's field of view that are not  
21 obscured by selected objects;  
22 supplementing the satellite system analysis program with a code segment that counts  
23 and records the quantity of pixels corresponding to obscured and unobscured  
24 portions of the sensor object's field of view at each of plural animation time steps;  
25 and  
26 supplementing the satellite system analysis program with a code segment that  
27 calculates, based on recorded quantities of pixels corresponding to obscured and  
28 unobscured portions of the sensor object's field of view at each of plural animation  
29 time steps, an obscuration percentage over a predetermined time period, the results  
30 of the calculations being reported to a user.

1 34. The computer program product for enabling a computer to upgrade a satellite  
2 system analysis program recited in claim 33, wherein the objects to be taken into account  
3 for obscuration analysis are selected from the group consisting of: the satellite,  
4 protrusions from the spacecraft, the central body about which the satellite orbits, and  
5 celestial bodies.

1 35. The computer program product for enabling a computer to upgrade a satellite  
2 system analysis program recited in claim 33, the predetermined operations further  
3 comprising:

4 supplementing the satellite system analysis program with a translation option for the  
5 sensor object that projects the sensor pattern from the edges of the sensor object.